Infrared thermography of electroconductive woven textiles

by J.Banaszczyk, G. De Mey

Department of Electronics and Information Systems, Ghent University, Sint Pietersniewstraat 41, 9000 Gent, Belgium

Abstract

Modelling of the current density in elelectroconductive textiles is a complicated problem as they cannot be considered homogenous structures with an isotropic current distribution. This anisotropy is mainly the result of the electrical contact resistance between interlacing yarns comprising the textile. It is difficult to measure the contact resistance directly as it is highly nonlinear and depends on many factors, however it can by inferred by comparing computer simulations of the power distribution in the textiles with their corresponding IR images.

1. Introduction

Electroconductive textiles are a relatively new but promising idea. The range of possible applications they could have in the future is very wide and spreads from medicine 2 to telecommunications 2 and wearable computing 2. Fibres can be used as conductors, which can be easily incorporated into clothing and form connections between electronic components 2, but they can also be made into textile sheets by means of e.g. weaving or knitting, to form e.g. antennas 2 or electrodes 2. In order to model the operation of such devices it is necessary to know their internal current distribution.

At first sight any piece of textile can be considered as a thin conducting sheet, which may be described by just one parameter: the sheet conductivity. However, in our previous paper 2 it was shown that this statement no longer holds for electroconductive textiles. Due to the electrical contact resistance between interlacing fibres a sheet of textile cannot always be considered a thin uniform and isotropic conductor.

An electroconductive textile sheet, be it woven or knitted, can be treated as a combination of series and parallel connections of resistors that correspond to the resistivity of the fibres themselves and to the resistance between fibres that are interlaced (contact resistance). These parameters will depend on numerous external factors such as the temperature, the humidity or the pressure and extension 2222. Furthermore, these may vary as a result of the device heating up during operation. This makes direct measurements of the contact resistance very problematic and that is why it is difficult to create a consistent current distribution model of the textile. Nonetheless, it is possible to infer the contact resistance by comparing the results of our simulations with the temperature distribution patterns we obtained through infrared imaging of actual electroconducting textile samples. A value of contact resistance can be found such that the simulated power distribution patterns closely resemble those of the temperature distribution in the infrared images.

2. Results

In Figure 1 the simulated power density for a sheet with the contact ratio equal to 240 (12Ω) is depicted. High power dissipation is visible in the vicinity of the contacts. Nonetheless the overall power distribution in the textile remains uniform. In Figure 2 the contact ratio is raised to 2000 (100Ω). It becomes clearly visible that the power is dissipated mostly along the electroconductive yarns and the pattern obtained is very similar to the infrared image of a real structure. Thus it can be concluded that the contact resistance in real electroconductive textiles is high and it influences the current distribution considerably.

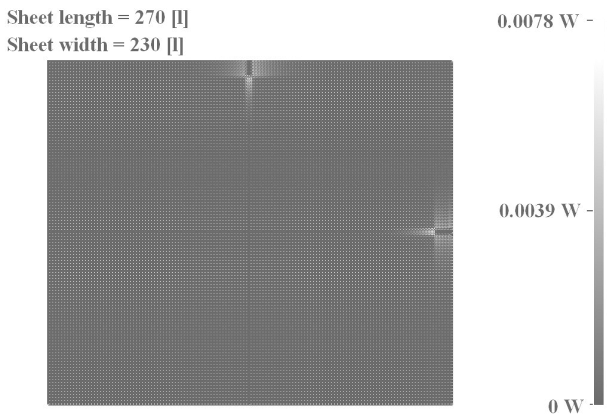

Figure 1: Simulated power density, $R_C / R = 240$ *(12Ω)*

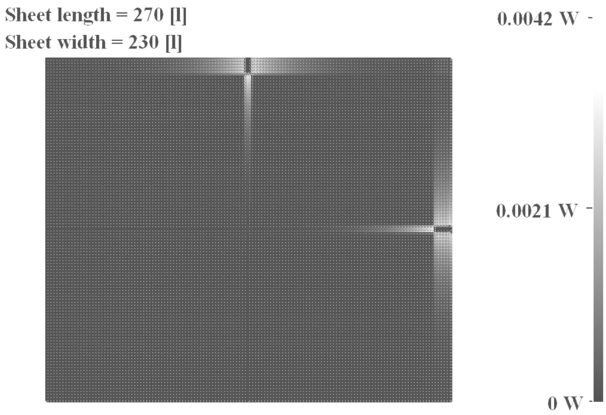

Figure2: Simulated power density, $R_C / R = 2000$ *(100Ω)*

Fig.3 shows the temperature distribution obtained with a thermographic camera. One observes that the thermal pattern agrees very well with the simulated power densities.

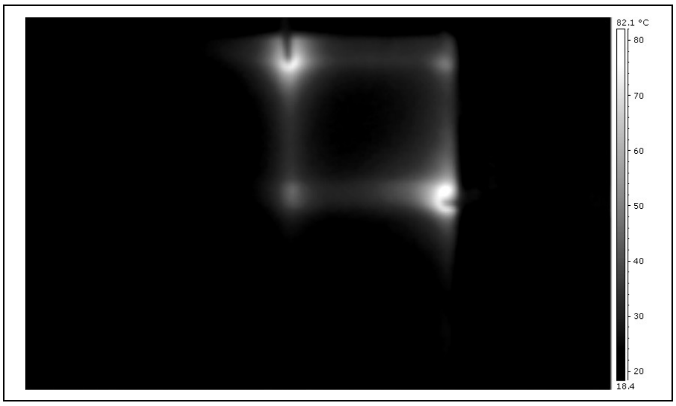

Figure 3: Temperature distribution, infrared image

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